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Models for flexible operation of buildings in district energy system Nordhavn

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An overview of a recently started project is given following. The project is a part of the “EnergyLab Nordhavn” project, whose general objective is to demonstrate for a city district such as the new Nordhavn, how electricity, heating, energy-efficient buildings and electric transport can be integrated into an intelligent, flexible and optimized energy system based on renewable energy. It is included in Work Package 3 on “Smart Energy Buildings”, which aims to provide new understanding of low-energy buildings with their occupants and users as active energy-flexible elements in a smart energy system, and to develop and demonstrate novel control solutions for smarter operation and monitoring of energy in modern buildings transforming challenging fluctuations of the various energy forms into an interconnected system.

The objective of the project is to contribute to the development of methods for modelling the dynamic thermal response of buildings that will facilitate energy flexibility, using energy storage and load shifting potentials. In this context, conceptual flexibility indicators are to be developed. Considering all parameters that could contribute to that, namely technical parameters of buildings, user behaviour and micro-climate around buildings, the purpose is to create models that can contribute to optimal control strategies. This derives from the base hypothesis that energy flexibility would enable the system to integrate a larger share of renewable energy and that energy flexibility in buildings, in particular, would have a key role in facilitating energy systems based entirely on renewable energy sources. It is the goal of the present project to examine whether and to which extent this could be verified and to provide methodologies to make such investigations.

A bottom-up modelling approach will be followed, working on the building level and having the energy system as the boundary condition. Categories of buildings will be studied with regards to their varying possibility for flexible operation, enabling shifting peak energy loads to off-peak hours. The different parameters that energy flexibility in buildings can be derived from will be studied and examined. This involves investigating the possibilities and the effects of storage both in the thermal mass of the building structures and by using different components and HVAC systems, for example Thermally Activated Building Structures (TABS) and heat pumps. Moreover, the study will focus on users’ comfort and behaviour. In this context users’ acceptability will be taken into consideration, investigating how the limits for comfort can be exploited and influenced. At the same time, the interaction between the users and the system will be also taken into account, on a design phase, examining how users affect the operation of the building. What is more, the micro-climate and other external influences will be considered, along with their effects on the operation of the buildings, identifying the contribution of different parameters such as solar gains and wind exposure. Experimental data from case buildings will be used to validate the models. Finally, a generic model engine will be created.

The main expected outcome of the project will be a methodology for simulating the dynamic thermal flexibility of buildings. Conceptual flexibility indicators will be delivered, in combination with the outcomes of the order of magnitude analysis of how the individual parameters affect the overall flexibility of the building. A simplified model will be provided, which will be used as input for model predictive control and aggregation modelling on city level.